Claims

1. (Withdrawn) A venous air removal device (VARD) of an extracorporeal blood circuit providing extracorporeal oxygenation of a patient's blood by drawing venous blood from the venous system of a patient through a venous return line and delivering oxygenated blood through an arterial line to the arterial system of the patient during cardiopulmonary bypass surgery adapted to be performed on the patient in the presence of a perfusionist, the VARD comprising:

a VARD housing enclosing a lower VARD chamber and an upper VARD chamber;'

an upper venous blood inlet through the VARD housing to the upper VARD chamber adapted to be coupled to the venous return line;

a lower venous blood outlet through the VARD housing to the lower VARD chamber adapted to be coupled to a blood pump to draw venous blood into the upper VARD chamber and out of the lower VARD chamber;

a purge port through the VARD housing to the upper VARD chamber;

an upper air sensor supported by the VARD housing in relation to the upper VARD chamber adapted to be powered to provide an electrical signal having a characteristic indicating the presence of air in the upper VARD chamber; and

a lower air sensor supported by the VARD housing in relation to the lower VARD chamber adapted to be powered to provide an electrical signal having a characteristic indicating the presence of air in the lower VARD chamber.

2. (Withdrawn) The VARD of Claim 1, wherein:

the upper air sensor comprises first and second piezoelectric elements mounted at respective first and second locations of the VARD housing having a portion of the upper VARD chamber between the first and second locations; and

the lower air sensor comprises third and fourth piezoelectric elements mounted at respective third and fourth locations of the VARD housing below the first and second piezoelectric elements.

3. (Withdrawn) The VARD of Claim 2, wherein the third and fourth locations are below the upper venous blood inlet.

4. (Withdrawn) The VARD of Claim 3, wherein:

the first and third piezoelectric elements are adapted to be coupled to an excitation source for applying element excitation signals to cause the first and third piezoelectric elements to emit acoustic energy; and

the second and fourth piezoelectric elements are coupled to signal processing circuitry for processing electrical signals generated in the second and fourth piezoelectric elements in response to acoustic energy emitted by the respective first and third piezoelectric elements and transmitted through any blood or air therebetween.

5. (Withdrawn) The VARD of Claim 4, wherein:

the first, second, third, and fourth piezoelectric elements are each rectangular having a element length, a element width shorter than the element length, and a element thickness;

the first piezoelectric element is mounted to the VARD housing at the first location with the element length extending in a first direction;

the second piezoelectric element is mounted to the VARD housing at the second location with the element length extending in a second direction substantially orthogonal to the first direction;

the third piezoelectric element is mounted to the VARD housing at the third location with the element length extending in a third direction; and

the fourth piezoelectric element is mounted to the VARD housing at the third location with the element length extending in a second direction substantially orthogonal to the fourth direction.

6. (Withdrawn) The VARD of Claim 5, wherein:

the first, second, third, and fourth piezoelectric elements comprise piezoelectric crystal layers having opposed major surfaces bearing conductive electrodes;

an electrical conductor is connected with each conductive electrode; and

the first, second, third, and fourth piezoelectric elements are mounted to the VARD housing with a conductive electrode disposed toward an exterior surface of the VARD housing at the respective first, second, third and fourth locations.

7. (Withdrawn) The VARD of Claim 6, wherein:

the VARD housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper VARD chamber and the lower VARD chamber;

the first and third piezoelectric elements are mounted to the volume displacer at the respective first and third locations; and

the second and third piezoelectric elements are mounted to cylindrical outer housing wall at the respective second and fourth locations.

8. (Withdrawn) The VARD of Claim 2, wherein:

the first and third piezoelectric elements are adapted to be coupled to an excitation source for applying element excitation signals to cause the first and third piezoelectric elements to emit acoustic energy; and

the second and fourth piezoelectric elements are adapted to be coupled to signal processing circuitry for processing electrical signals generated in the second and fourth piezoelectric elements in response to acoustic energy emitted by the respective first and third piezoelectric elements and transmitted through any blood or air therebetween.

9. (Withdrawn) The VARD of Claim 8, wherein:

the first, second, third, and fourth piezoelectric elements are each rectangular having a element length, a element width shorter than the element length, and a element thickness;

the first piezoelectric element is mounted to the VARD housing at the first location with the element length extending in a first direction;

the second piezoelectric element is mounted to the VARD housing at the second location with the element length extending in a second direction substantially orthogonal to the first direction;

the third piezoelectric element is mounted to the VARD housing at the third location with the element length extending in a third direction; and

the fourth piezoelectric element is mounted to the VARD housing at the third location with the element length extending in a second direction substantially orthogonal to the fourth direction.

10. (Withdrawn) The VARD of Claim 9, wherein:

the first, second, third, and fourth piezoelectric elements comprise piezoelectric crystal layers having opposed major surfaces bearing conductive electrodes;

an electrical conductor is connected with each conductive electrode; and

the first, second, third, and fourth piezoelectric elements are mounted to the VARD housing with a conductive electrode disposed toward an exterior surface of the VARD housing at the respective first, second, third and fourth locations.

11. (Withdrawn) The VARD of Claim 10, wherein the electrical conductors extend to connector elements of a VARD connector adapted to coupled to a cable connector of a VARD cable, the VARD connector having a further pair of connector elements coupled together to enable a continuity check to be performed through a pair of conductors of the VARD cable when the cable connector is properly connected to the VARD cable.

12. (Withdrawn) The VARD of Claim 10, wherein:

the VARD housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper VARD chamber and the lower VARD chamber;

the first and third piezoelectric elements are mounted to the volume displacer at the respective first and third locations; and

the second and fourth piezoelectric elements are mounted to the cylindrical outer housing wall at the respective second and fourth locations.

13. (Withdrawn) The VARD of Claim 1, wherein:

the VARD housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper VARD chamber and the lower VARD chamber;

the upper air sensor is mounted to the VARD housing in relation to the upper VARD chamber between the volume displacer and the outer housing wall; and

the lower air sensor is mounted to the VARD housing in relation to the lower VARD chamber between the volume displacer and the outer housing wall.

14. (Withdrawn) The VARD of Claim 13, wherein the lower air sensor is mounted below the upper venous blood inlet.

15. (Withdrawn) The VARD of Claim 1, wherein the lower air sensor is mounted below the upper venous blood inlet.

16. (Withdrawn) The VARD of Claim 1, wherein:

the upper and lower air sensors are coupled through electrical conductors to connector elements of a VARD connector adapted to coupled to a cable connector of a VARD cable; and

the VARD connector has a pair of connector elements coupled together to enable a continuity check to be performed through a pair of conductors of the VARD cable when the cable connector is properly connected to the VARD cable.

17. (Withdrawn) An extracorporeal blood circuit providing extracorporeal oxygenation of a patient's blood by drawing venous blood from the venous system of a patient through a venous return line and delivering oxygenated blood through an arterial line to the arterial system of the patient during cardiopulmonary bypass surgery adapted to be performed on the patient in the presence of a perfusionist, the extracorporeal blood circuit comprising:

a venous air removal device (VARD) comprising:

a VARD housing enclosing a lower VARD chamber and an upper VARD chamber;'

an upper venous blood inlet through the VARD housing to the upper VARD chamber coupled to the venous return line;

a lower venous blood outlet through the VARD housing to the lower VARD chamber;

a VARD purge port through the VARD housing to the upper VARD chamber;

an upper air sensor supported by the VARD housing in relation to the upper VARD chamber; and

a lower air sensor supported by the VARD housing in relation to the lower VARD chamber;

a blood pump coupled to the lower venous blood outlet to draw venous blood through the venous return line into the upper VARD chamber and out of the lower VARD chamber, whereby venous blood accumulates in the lower VARD chamber and any air bubbles accumulate in the upper VARD chamber;

means for powering the upper air sensor to provide an upper sensor signal having a characteristic indicating the presence of air in the upper VARD chamber; and

means for powering the lower air sensor to provide a lower sensor signal having a characteristic indicating the presence of air in the lower VARD chamber.

18. (Withdrawn) The extracorporeal blood circuit of Claim 17, further comprising means responsive to an upper sensor signal characteristic indicating the presence of air in the upper VARD chamber for applying suction to the VARD purge port to purge air from the upper VARD chamber.

19. (Withdrawn) The extracorporeal blood circuit of Claim 18, further comprising means responsive to a lower sensor signal characteristic indicating the presence of air in the lower VARD chamber for applying suction to the VARD purge port to purge air from the lower VARD chamber.

20. (Withdrawn) The extracorporeal blood circuit of Claim 17, further comprising means responsive to a lower sensor signal characteristic indicating the presence of air in the lower VARD chamber for applying suction to the VARD purge port to purge air from the lower VARD chamber.

21. (Withdrawn) The extracorporeal blood circuit of Claim 17, further comprising:

a blood oxygenator coupled to the blood pump to receive and oxygenate the venous blood pumped from the lower VARD chamber;

an arterial filter coupled to the blood oxygenator comprising:

an arterial filter housing enclosing a lower arterial filter blood chamber and an upper arterial filter blood inlet chamber;'

an upper arterial filter blood inlet through the arterial filter housing to the upper arterial filter blood inlet chamber coupled to the blood oxygenator;

a lower arterial filter blood outlet through the arterial filter housing to the lower arterial filter blood chamber; and

an arterial filter purge port through the arterial filter housing to the upper arterial filter blood inlet chamber;

an arterial filter recirculation line extending between the arterial filter purge port and the venous return line coupled to the upper venous blood inlet, whereby air accumulating in the upper arterial filter inlet chamber is drawn by the blood pump into the upper VARD chamber.

22. (Withdrawn) The extracorporeal blood circuit of Claim 21, further comprising means responsive to an upper sensor signal characteristic indicating the presence of air in the upper VARD chamber for applying suction to the VARD purge port to purge air from the upper VARD chamber.

23. (Withdrawn) The extracorporeal blood circuit of Claim 22, further comprising means responsive to a lower sensor signal characteristic indicating the presence of air in the lower VARD chamber for applying suction to the VARD purge port to purge air from the lower VARD chamber.

24. (Withdrawn) The extracorporeal blood circuit of Claim 21, further comprising means responsive to a lower sensor signal characteristic indicating the presence of air in the lower VARD chamber for applying suction to the VARD purge port to purge air from the lower VARD chamber.

25. (Withdrawn) A method for providing extracorporeal oxygenation of a patient's blood during cardiopulmonary bypass surgery adapted to be performed in the presence of a perfusionist and employing a venous return line and an arterial line connected to the respective venous and arterial systems of the patient, the method comprising:

drawing venous blood and any air bubbles therein from the patient through the venous return line and through an upper venous blood inlet of a venous air removal device (VARD) coupled thereto, thereby accumulating venous blood in a lower VARD chamber and any air bubbles in an upper VARD chamber;

pumping venous blood from the lower VARD chamber through the blood oxygenator and oxygenated blood from the blood oxygenator into the arterial line;

sensing any air accumulating in the upper VARD chamber;

purging air from the upper VARD chamber;

sensing any air accumulating in the lower VARD chamber; and

when air is sensed in the lower VARD chamber, alerting the perfusionist that too much air is being accumulated in the VARD and to take appropriate corrective action.

26. (Withdrawn) The method of Claim 25, further comprising purging air from the lower VARD chamber through the upper VARD chamber when air is sensed in the lower VARD chamber.

27. (Withdrawn) The method of Claim 26, wherein the drawing and pumping steps further comprise:

connecting a blood pump inlet of a blood pump to a venous blood outlet of the VARD and a blood pump outlet to a venous blood inlet of the blood oxygenator connected to the arterial line; and

operating the blood pump to draw venous blood and any air bubbles therein through the upper venous blood inlet of the VARD, thereby accumulating venous blood in the lower VARD chamber and any air bubbles in the upper VARD chamber, and to pump venous blood from the lower VARD chamber through the blood oxygenator and oxygenated blood from the blood oxygenator into the arterial line.

28. (Withdrawn) The method of Claim 27, further comprising:

connecting an arterial filter inlet of an arterial filter to an oxygenated blood outlet of the blood oxygenator and a lower arterial filter oxygenated blood outlet to the arterial line, the arterial filter having an upper arterial filter inlet chamber and a lower arterial blood chamber, whereby any air in the oxygenated blood accumulates in the upper arterial filter inlet chamber; and

connecting the upper arterial filter inlet chamber to the upper inlet chamber of the VARD, whereby air accumulating in the upper arterial filter inlet chamber is drawn into and purged from the upper VARD chamber.

29. (Withdrawn) The method of Claim 25, wherein the drawing and pumping steps further comprise:

connecting a blood pump inlet of a blood pump to a venous blood outlet of the VARD and a blood pump outlet to a venous blood inlet of the blood oxygenator connected to the arterial line; and

operating the blood pump to draw venous blood and any air bubbles therein through the upper venous blood inlet of the VARD, thereby accumulating venous blood

in the lower VARD chamber and any air bubbles in the upper VARD chamber, and to pump venous blood from the lower VARD chamber through the blood oxygenator and oxygenated blood from the blood oxygenator into the arterial line.

30. (Withdrawn) The method of Claim 29, further comprising:

connecting an arterial filter inlet of an arterial filter to an oxygenated blood outlet of the blood oxygenator and a lower arterial filter oxygenated blood outlet to the arterial line, the arterial filter having an upper arterial filter inlet chamber and a lower arterial blood chamber, whereby any air in the oxygenated blood accumulates in the upper arterial filter inlet chamber; and

connecting the upper arterial filter inlet chamber to the upper inlet chamber of the VARD, whereby air accumulating in the upper arterial filter inlet chamber is drawn into and purged from the upper VARD chamber.

31. (Withdrawn) A method for providing extracorporeal oxygenation of a patient's blood during cardiopulmonary bypass surgery adapted to be performed in the presence of a perfusionist and employing a venous return line and an arterial line coupled to the respective venous and arterial systems of the patient, the method comprising:

connecting an upper venous blood inlet of a venous air removal device (VARD) to the venous return line, the VARD having a VARD housing enclosing a lower VARD chamber and an upper VARD chamber;

connecting a blood pump inlet of a blood pump to a venous blood outlet of the VARD and a blood pump outlet to a venous blood inlet of a blood oxygenator having an oxygenated blood outlet;

connecting an arterial filter inlet of an arterial filter to the oxygenated blood outlet of the blood oxygenator and a lower arterial filter oxygenated blood outlet to the arterial line, the arterial filter having an upper arterial filter inlet chamber and a lower arterial

blood chamber, whereby any air in the oxygenated blood accumulates in the upper arterial filter inlet chamber;

connecting the upper arterial filter inlet chamber to the upper inlet chamber of the VARD, whereby air accumulating in the upper arterial filter inlet chamber is drawn into and purged from the upper VARD chamber.

operating the blood pump to draw venous blood and any air bubbles therein through the upper venous blood inlet of the VARD, thereby accumulating venous blood in the lower VARD chamber and any air bubbles in the upper VARD chamber, and to pump venous blood from the lower VARD chamber through the blood oxygenator and oxygenated blood from the blood oxygenator into the arterial filter and from the arterial filter into the arterial line;

sensing any air accumulating in the upper VARD chamber; and

purging air from the upper VARD chamber.

32. (Withdrawn) The method of Claim 31, further comprising connecting the upper arterial filter inlet chamber to the upper inlet chamber of the VARD, whereby air accumulating in the upper arterial filter inlet chamber is drawn into and purged from the upper VARD chamber.

33. (Withdrawn) The method of Claim 32, further comprising

sensing any air accumulating in the lower VARD chamber; and

when air is sensed in the lower VARD chamber, alerting the perfusionist that too much air is being accumulated in the VARD and to take appropriate corrective action.

34. (Withdrawn) The method of Claim 31, further comprising

sensing any air accumulating in the lower VARD chamber; and

when air is sensed in the lower VARD chamber, alerting the perfusionist that too much air is being accumulated in the VARD and to take appropriate corrective action.

35. (Withdrawn) An air removal device of an extracorporeal blood circuit providing extracorporeal oxygenation of a patient's blood by drawing venous blood from the venous system of a patient through a venous return line and delivering oxygenated blood through an arterial line to the arterial system of the patient during cardiopulmonary bypass surgery adapted to be performed on the patient in the presence of a perfusionist, the air removal device comprising:

an air removal device housing enclosing a lower blood chamber and an upper blood inlet chamber;'

an upper blood inlet through the air removal device housing to the upper blood inlet chamber adapted to be coupled to the return line;

a lower blood outlet through the air removal device housing to the lower blood chamber adapted to be coupled to a blood pump to draw blood into the upper blood inlet chamber and out of the lower blood chamber;

a purge port through the air removal device housing to the upper blood inlet chamber;

an upper air sensor supported by the air removal device housing in relation to the upper blood inlet chamber adapted to be powered to provide an electrical signal having a characteristic indicating the presence of air in the upper blood inlet chamber; and

a lower air sensor supported by the air removal device housing in relation to the lower blood chamber adapted to be powered to provide an electrical signal having a characteristic indicating the presence of air in the lower blood chamber.

36. (Withdrawn) The air removal device of Claim 35, wherein:

the upper air sensor comprises first and second piezoelectric elements mounted at respective first and second locations of the air removal device housing having a portion of the upper blood inlet chamber between the first and second locations; and

the lower air sensor comprises third and fourth piezoelectric elements mounted at respective third and fourth locations of the air removal device housing below the first and second piezoelectric elements.

37. (Withdrawn) The air removal device of Claim 36, wherein the third and fourth locations are below the upper blood inlet.

38. (Withdrawn) The air removal device of Claim 36, wherein:

the first and third piezoelectric elements are adapted to be coupled to an excitation source for applying element excitation signals to cause the first and third piezoelectric elements to emit acoustic energy; and

the second and fourth piezoelectric elements are adapted to be coupled to signal processing circuitry for processing electrical signals generated in the second and fourth piezoelectric elements in response to acoustic energy emitted by the respective first and third piezoelectric elements and transmitted through any blood or air therebetween.

39. (Withdrawn) The air removal device of Claim 36, wherein:

the first, second, third, and fourth piezoelectric elements are each rectangular having a element length, a element width shorter than the element length, and a element thickness;

the first piezoelectric element is mounted to the air removal device housing at the first location with the element length extending in a first direction;

the second piezoelectric element is mounted to the air removal device housing at the second location with the element length extending in a second direction substantially orthogonal to the first direction;

the third piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a third direction; and

the fourth piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a second direction substantially orthogonal to the fourth direction.

40. (Withdrawn) The air removal device of Claim 36, wherein:

the first, second, third, and fourth piezoelectric elements comprise piezoelectric crystal layers having opposed major surfaces bearing conductive electrodes;

an electrical conductor is connected with each conductive electrode; and

the first, second, third, and fourth piezoelectric elements are mounted to the air removal device housing with a conductive electrode disposed toward an exterior surface of the air removal device housing at the respective first, second, third and fourth locations.

41. (Withdrawn) The air removal device of Claim 36, wherein:

the air removal device housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper blood inlet chamber and the lower blood chamber;

the first and third piezoelectric elements are mounted to the volume displacer at the respective first and third locations; and

the second and third piezoelectric elements are mounted to cylindrical outer housing wall at the respective second and fourth locations.

42. (Withdrawn) The air removal device of Claim 35, wherein:

the first and third piezoelectric elements are adapted to be coupled to an excitation source for applying element excitation signals to cause the first and third piezoelectric elements to emit acoustic energy; and

the second and fourth piezoelectric elements are adapted to be coupled to signal processing circuitry for processing electrical signals generated in the second and fourth piezoelectric elements in response to acoustic energy emitted by the respective first and third piezoelectric elements and transmitted through any blood or air therebetween.

43. (Withdrawn) The air removal device of Claim 35, wherein:

the first, second, third, and fourth piezoelectric elements are each rectangular having a element length, a element width shorter than the element length, and a element thickness;

the first piezoelectric element is mounted to the air removal device housing at the first location with the element length extending in a first direction;

the second piezoelectric element is mounted to the air removal device housing at the second location with the element length extending in a second direction substantially orthogonal to the first direction;

the third piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a third direction; and

the fourth piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a second direction substantially orthogonal to the fourth direction.

44. (Withdrawn) The air removal device of Claim 35, wherein:

the first, second, third, and fourth piezoelectric elements comprise piezoelectric crystal layers having opposed major surfaces bearing conductive electrodes;

an electrical conductor is connected with each conductive electrode; and

the first, second, third, and fourth piezoelectric elements are mounted to the air removal device housing with a conductive electrode disposed toward an exterior surface of the air removal device housing at the respective first, second, third and fourth locations.

45. (Withdrawn) The air removal device of Claim 44, wherein the electrical conductors extend to connector elements of an air removal device connector adapted to coupled to a cable connector of an air removal device cable, the air removal device connector having a further pair of connector elements coupled together to enable a continuity check to be performed through a pair of conductors of the air removal device cable when the cable connector is properly connected to the air removal device cable.

46. (Withdrawn) The air removal device of Claim 44, wherein:

the air removal device housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper blood inlet chamber and the lower blood chamber;

the first and third piezoelectric elements are mounted to the volume displacer at the respective first and third locations; and

the second and fourth piezoelectric elements are mounted to the cylindrical outer housing wall at the respective second and fourth locations.

47. (Withdrawn) The air removal device of Claim 35, wherein:

the air removal device housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper blood inlet chamber and the lower blood chamber;

the upper air sensor is mounted to the air removal device housing in relation to the upper blood inlet chamber between the volume displacer and the outer housing wall; and

the lower air sensor is mounted to the air removal device housing in relation to the lower blood chamber between the volume displacer and the outer housing wall.

48. (Withdrawn) The air removal device of Claim 47, wherein the lower air sensor is mounted below the upper blood inlet.

49. (Withdrawn) The air removal device of Claim 35, wherein the lower air sensor is mounted below the upper blood inlet.

50. (Withdrawn) The air removal device of Claim 35, wherein:

the upper and lower air sensors are coupled through electrical conductors to connector elements of an air removal device connector adapted to coupled to a cable connector of an air removal device cable; and

the air removal device connector has a pair of connector elements coupled together to enable a continuity check to be performed through a pair of conductors of the air removal device cable when the cable connector is properly connected to the air removal device connector.

51. (Amended) An air removal device of an extracorporeal blood circuit providing extracorporeal oxygenation of a patient's blood by drawing venous blood from the venous system of a patient through a venous return line and delivering oxygenated blood through an arterial line to the arterial system of the patient during cardiopulmonary bypass surgery adapted to be performed on the patient in the presence of a perfusionist, the air removal device comprising:

an air removal device housing enclosing a lower blood chamber and an upper blood inlet chamber;

an upper blood inlet through the air removal device housing to the upper blood inlet chamber [[adapted]] <u>that is sized and shaped</u> to be coupled to the return line;

a lower blood outlet through the air removal device housing to the lower blood chamber [[adapted]] that is sized and shaped to be coupled to a blood pump to draw blood into the upper blood inlet chamber and out of the lower blood chamber;

a purge port through the air removal device housing to the upper blood inlet chamber;

an upper air sensor comprising first and second piezoelectric elements [[supported within respective first and second slots]] at respective first and second locations of the air removal device housing having a portion of the upper blood inlet chamber between the first and second locations, the first and second locations being separated by a first distance; [[and]]

a lower air sensor [[comprises]] comprising third and fourth piezoelectric elements [[supported within respective third and fourth slots]] at respective third and fourth locations of the air removal device housing that are below the first and second piezoelectric elements, the third and fourth locations being separated by a second distance; and

wherein the first distance is different than the second distance.

52. (Amended) The air removal device of Claim 51, wherein the first, second, third and fourth piezoelectric elements are adhered into [[the respective]] first, second, third and fourth slots.

53. (Original) The air removal device of Claim 52, wherein:

the first and third piezoelectric elements are adapted to be coupled to an excitation source for applying element excitation signals to cause the first and third piezoelectric elements to emit acoustic energy; and

the second and fourth piezoelectric elements are adapted to be coupled to signal processing circuitry for processing electrical signals generated in the second and fourth

piezoelectric elements in response to acoustic energy emitted by the respective first and third piezoelectric elements and transmitted through any blood or air therebetween.

54. (Amended) The air removal device of Claim 52, wherein:

the first, second, third, and fourth piezoelectric elements are each rectangular having an element length, an element width shorter than the element length, and an element thickness;

the first piezoelectric element is mounted to the air removal device housing at the first location with the element length extending in a first direction;

the second piezoelectric element is mounted to the air removal device housing at the second location with the element length extending in a second direction substantially orthogonal to the first direction;

the third piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a third direction; and

the fourth piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a second direction substantially orthogonal to the fourth direction.

55. (Original) The air removal device of Claim 52, wherein:

the first, second, third, and fourth piezoelectric elements comprise piezoelectric crystal layers having opposed major surfaces bearing conductive electrodes;

an electrical conductor is connected with each conductive electrode; and

the first, second, third, and fourth piezoelectric elements are mounted into a slot of the air removal device housing with a conductive electrode disposed toward an exterior surface of the air removal device housing at the respective first, second, third and fourth locations.

56. (Original) The air removal device of Claim 52, wherein:

the air removal device housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper blood inlet chamber and the lower blood chamber;

the first and third piezoelectric elements are mounted to the volume displacer at the respective first and third locations; and

the second and third piezoelectric elements are mounted to cylindrical outer housing wall at the respective second and fourth locations.

57. (Original) The air removal device of Claim 51, wherein:

the first and third piezoelectric elements are adapted to be coupled to an excitation source for applying element excitation signals to cause the first and third piezoelectric elements to emit acoustic energy; and

the second and fourth piezoelectric elements are adapted to be coupled to signal processing circuitry for processing electrical signals generated in the second and fourth piezoelectric elements in response to acoustic energy emitted by the respective first and third piezoelectric elements and transmitted through any blood or air therebetween.

58. (Amended) The air removal device of Claim 51, wherein:

the first, second, third, and fourth piezoelectric elements are each rectangular having an element length, an element width shorter than the element length, and an element thickness;

the first piezoelectric element is mounted to the air removal device housing at the first location with the element length extending in a first direction;

the second piezoelectric element is mounted to the air removal device housing at the second location with the element length extending in a second direction substantially orthogonal to the first direction;

the third piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a third direction; and

the fourth piezoelectric element is mounted to the air removal device housing at the third location with the element length extending in a second direction substantially orthogonal to the fourth direction.

59. (Original) The air removal device of Claim 51, wherein:

the first, second, third, and fourth piezoelectric elements comprise piezoelectric crystal layers having opposed major surfaces bearing conductive electrodes;

an electrical conductor is connected with each conductive electrode; and

the first, second, third, and fourth piezoelectric elements are mounted into the air removal device housing slot with a conductive electrode disposed toward an exterior surface of the air removal device housing at the respective first, second, third and fourth locations.

60. (Original) The air removal device of Claim 59, wherein the electrical conductors extend to connector elements of an air removal device connector adapted to coupled to a cable connector of an air removal device cable, the air removal device connector having a further pair of connector elements coupled together to enable a continuity check to be performed through a pair of conductors of the air removal device cable when the cable connector is properly connected to the air removal device cable.

61. (Original) The air removal device of Claim 51, wherein:

the air removal device housing has a substantially cylindrical outer housing wall extending between opposed end walls and enclosing a substantially cylindrical cavity, a substantially tubular volume displacer extends substantially axially into the cylindrical cavity from an end wall to define and reduce the volume of the upper blood inlet chamber and the lower blood chamber;

the first and third piezoelectric elements are mounted to the volume displacer at the respective first and third locations; and

the second and fourth piezoelectric elements are mounted to the cylindrical outer housing wall at the respective second and fourth locations.